The Mysterious Ditonal Sandhi Gaps in Tianjin♠

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Abstract

There are two mysterious gaps in Tianjin ditonal sandhi that have hitherto not received the attention they deserve. With two tonal features [high] and [low], Tianjin has an inventory of four tones, L(ow), H(igh), R(ising) and F(alling), six of their eight possible combinations trigger sandhi: LL→RL, RR→HR, FF→LF, FL→HL, RF→LF and RH→LH. Evidently, OCP is the trigger, applying at two different levels of the tone structure: the contour as a unit and the constituent tone features. This leaves two mysterious gaps as HH and FR do not undergo sandhi. In this paper, the mystery is solved through the recognition that Tianjin prosody is rightheaded and that tonal features contribute to prosodic weight.
Keywords: Tone sandhi, tone contour, tone feature, prosodic weight, OCP, Tianjin

1. Introduction

The city of Tianjin, approximately 120 kilometers south of Beijing, is home to a northern variety of Mandarin where there are four lexical tones: L(ow), H(igh), R(ising), F(alling). When these are put together to form ditonal sequences, tone sandhi applies to six of 16 possible ditonal collocations.[1]

(1) Tonal inventory and Ditonal Sandhi in Tianjin (data from Wee, Yan and Chen 2005)

L(ow), H(igh), R(ising), F(alling)

a. LL → RL
  i. *feiL jiL* → *feiR jiL* 'fly machine (=airplane)'
  ii. *kaiL cheL* → *kaiR cheL* 'drive car'

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[1] Four which (1a-d) were first documented by Li and Liu (1981), (1e,f) were uncovered by Wee, Yan and Chen (2005). Ma and Jia (2006) however are doubtful of the existence of (1e,f).

b. RR → HR

i. *zongR liR* → *zongH liR* ‘overall manage (=prime minister)’

ii. *xuanR juR* → *xuanH juR* ‘select support (=election)’

c. FF → LF

i. *fuF guiF* → *fuL guiF* ‘prosperity expensive (=prosperous)’

ii. *shiF jieF* → *shiL jieF* ‘world domain (=world)’

d. FL →HL

i. *siF fangL* → *siH fangL* ‘four square (=square)’

ii. *qiF cheL* → *qiH cheL* ‘gas vehicle (=car)’

e. RF → LF

i. *banR dengF* → *banL dengF* ‘board chair (=bench)’

ii. *shouR duanF* → *shouL duanF* ‘hand segment (=methods, means)’

f. RH → LH

i. *zhaoR qianH* → *zhaoL qianH* ‘find money (=give change)’

ii. *zhuR renH* → *zhuL renH* ‘master person (=master/mistress)’

Given the rudimentary ditonal sandhi patterns in (1), two gaps appear rather mysterious.

(2) The Mysterious Gaps

a. HH → *FH

i. *changH chengH* ‘the Great Wall’

ii. *hongH tangH* ‘red sugar’

b. FR → *HR

i. *shiF zhangR* ‘city elder (=mayor)’

ii. *paF siR* ‘afraid (of) death’

It is puzzling that HH does not undergo sandhi when all other collocations of identical tones do. Likewise, if RF, RH and FL undergo sandhi, one would expect FR to do so as well. The mysterious gaps in (2) have never been addressed by the very many scholars who studied Tianjin tone sandhi (Li & Liu 1981; Chen 1986, 2000; Zhang 1987; Milliken et al 1997; Lin 2008; Wee 2004, 2010; Wee, Yan and Chen 2005; among others).

This paper addresses the gaps by arguing that the Tianjin tones are made up of tonal feature units which affect prominence very much the same way heavy rimes in non-tonal languages like English do (recall weight-to-stress principle, which according to Duanmu 2009:58f, goes back as far as Prokosch 1939, Fudge 1969, Hoard 1971, Bailey 1978, Selkirk 1982, Murray and Vennemann 1983, Kager 1989, Prince 1990, Wells 1990, Hammond 1999, and Duanmu 2000). The tone sandhi patterns are thus demonstrated to be the result of intricate interaction between the iambic prosodic default of Tianjin and the OCP with reference to the weightedness of each tone contour.

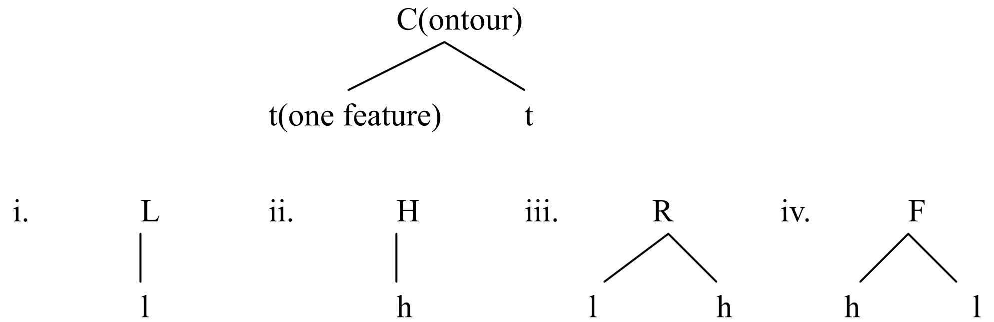
The subsequent sections are organized as follows. Section 2 discusses the role of OCP on Tianjin tone sandhi and demonstrates why the mysterious gaps require an account. The account is given in section 3 using a combination of OCP and an apparently ad hoc constraint *tt.t that forbids contour tones to precede simplex ones in a ditonal sequence. Section 4 explores the ramifications of the solution and reveals the structural representation of tone to be a contour unit composed of a sequence of level tone features and that these level tone features in turn interact with the rightheaded prosody of Tianjin. All these lead to section 5 where the secret behind the constraint *tt.t is unraveled as founded on the idea that tone features contribute to prosodic weight. Some evidence is provided, including a simple perceptual experiment reported in section 6. Section 7 offers a brief conclusion.

2. OCP as Sandhi Trigger on Contour Tones

2.1 Compositionality of Tianjin Contour Tones

With respect to the Tianjin ditonal sandhi patterns, Yip (1989) observes that (1a,b,c) are really cases of the OCP applying at the level of the tone contour. However, the nature of contour tones has been a matter of some debate. Yip (1980:40, 1989) was among the first to argue that that tone contours are made of sequenced tone features. By that token, the four tones in Tianjin may be understood (5).

(5) Tones in Tianjin



Whether contour tones are made up of units of level tones, is a matter of some debate (see Yip 2002, section 3.3 for an excellent summary). Some Chinese languages such as Hangzhou Chinese (Hsieh 2008) demonstrably argue that tone contours are non-compositional. Barrie (2007), on the other hand, notes that compositionality of contour tones is well-evidenced in Afircan tonal languages and suggests that tonal languages may differ depending on whether contours are unitary units or clusters of tonal features.

So, are contour tones in Tianjin made up of units of level tones or are they non-compositional? The sandhi-patterns in (1a,b,c) demonstrates that the tone contours are singular units to which the OCP applies. However, the sandhi patterns in (1d,e,f) requires and account that construes the Tianjin contour tones as composed of units of sequenced level tones. Evidently then, the representations in (5) would be most useful for understanding Tianjin tone sandhi because they explain how the OCP can apply at the level of tone features and at the level of tone contour which is a constituency of the subordinate features (more in section 4.1).

2.2 OCP effects on tonal contours

As mentioned earlier, Yip (1989) observes that (1a,b,c) are really cases of the OCP applying at the level of the tone contour, though one would need an explanation as to why HH adjacencies do not trigger tone sandhi.[2]

Beyond simplistically saying that the OCP applies with the exception of HH adjacencies, Optimality Theory (Prince and Smolensky 1993/2004) offers a straightforward way to capture this pattern: a family of OCP[Contour] constraints where faithfulness constraints are ranked between OCP[L, R, F] and OCP[H], as in (6).

(6) Preventing HH from triggering tone sandhi

OCP[C]
Identical adjacent tone contours are forbidden.
MAX[t]
Do not delete any tone feature.
DEP[t]
Do not insert any tone feature.

OCP [L, R, F] » MAX [t]; DEP [t] » OCP [H]

The ranking hierarchy in (6) ensures that H does not change into F or R to satisfy OCP[H]

[2] Yip's (1989) solution is to assume that H is unspecified, while Chen's (2000:110) simply states HH as an exception to the OCP. Neither solution is unviable because RF and RH trigger sandhi, so the [h] tone feature must be active.

since such alternation would incur a violation of the higher DEP[t] constraint. Deleting the H would not work either since that would involve the deletion of the [h] tone feature, violating MAX[t], also higher ranked than OCP[H]. This is demonstrated in the following tableaux.

(7) OT account of why HH does not trigger tone sandhi[3]

a. /LL/	OCP[L, R, F]	MAX[t]	DEP[t]	OCP[H]
i. LL	*!			
☞ii. RL			*	

b. /RR/				
i. RR	*!			
☞ii. HR		*		

c. /FF/				
i. FF	*!			
☞ii. LF		*		

d. /HH/				
☞i. HH				*
ii. XH		*(?)!	*(?)	

Legend: ☞ indicates optimal and attested candidate
* indicates number of violations
! indicates crucial violation

In (7), inputs are given on the top lefthand corner of each tableau. Along the first row constraints are listed in order of dominance from left-to-right, with dotted lines indicating constraints that are not ranked with respect to one another. As may be seen in (7), high-ranking OCP warrants sandhi for inputs such as /LL/, /RR and /FF/.However, the domination of MAX[t] and DEP[t] over OCP[H] would prevent sandhi from applying. No matter what X is in (7dii), either MAX[t], DEP[t] or even both would be violated (the "?" in that tableau indicates these various possibilities).

2.3 OCP effects on tonal features

Next, consider the sandhi patterns in (1d,e,f). Common to the sandhi-triggering ditonal sequences FL, RH and RF is the adjacency of identical tone features: [l] in the case of FL (i.e.

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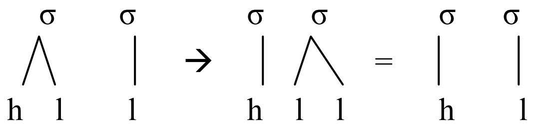
[3] I ignore for the moment candidates where the second tone changes. This can be easily done with a positional faithfulness constraint on the second tone that dominates all other constraints, more later in section 5.1.

hl.l) or [h] in the case of RH and RF (i.e. lh.h and lh.hl respectively). As Chen (2000:106, citing Hyman and Schuh 1974) explains, these are cases of tone absorption where an OCP-offending tone feature adjacency undergoes a rightward shift.[4]

(8) Tonal Absorption



(cf. (1d), FL → HL)

At first blush, tonal absorption appears to be a phonetic issue of articulatory overlap as one tone anticipates the next, triggered perhaps by the inability to produce a contour tone in anticipation of the following pitch height. However, tonal absorption as seen in (1d,e,f) cannot be reduced to a purely phonetic account because of sandhi gaps like FR where the F does not become H. In other words, one cannot, on the basis of FL→ HL, RF→LF and RH→LH conclude that the process is due to response time needed by the vocal folds to execute the tone contour. Tone absorption would require a phonological account. Thus all alternation rules in (1) must be part of the phonological system of Tianjin.

The absorption phonological account for (1d,e,f) would require OCP to apply at the level of tone features.

(9) Triggering Absorption

OCP[t]

Identical adjacent tone features are forbidden.

OCP[h, l] >> MAX[t]; DEP[t]

To get the absorption effects, OCP[h] and OCP[l] would have to outrank MAX[t] and DEP[t], as shown in (10).

[4] Bamileke, Mende, Kikuyu, Hausa, Ngizim, among others have been identified by Hyman and Schuh (1974) as among the many languages where such absorption processes occur. It is also possible to think of absorption as simply the deletion of the second tone feature of the first syllable in such OCP[t] offending situations.

(10) OT account of why FR, RH, RF triggers tone sandhi

a. /FL/	OCP[t]	MAX[t]	DEP[t]
i. hl.l (=FL)	*		
☞ii. h.l (=HL)		*	

b. /RF/			
i. lh.hl (=RF)	*		
☞ii. l.hl (=LF)		*	

c. /RH/			
i. lh.h (=RH)	*		
☞ii. l.h (=LH)		*	

An account such as (10) is problematic for two reasons. Firstly, it predicts that FR should undergo alternation to become HR, contrary to fact. Secondly, high-ranking OCP[t] erroneously predict that HH (which is h.h) would undergo alternation to become FH, undoing the work of the account in (6). Hence, one arrives at the mysterious sandhi gaps in as listed in (2), repeated here as (11).

(11) The Mysterious Ditonal Sandhi Gaps

a. HH → *FH

b. FR → *HR

The presence of these gaps is not an OT-specific problem. It is a general problem that falls out of the OCP-triggered nature of the Tianjin tone sandhi patterns. The ensuing section attempts at a solution through recognizing a common property in the tonal combinations of sandhied forms that satisfy OCP[t].

3. A Solution However Unlikely

Beyond satisfaction of the OCP[t], there is one other thing that ditonal sandhis (1d,e,f) have in common. In all three cases, the output form has a tonal configuration where the first syllable bears a simple tone, FL → HL; RF → LF; and RH→LH. The second syllable may either bear a simple tone (L or H) or a contour tone (F). Using this as a handle for finding a solution to the mysterious gaps, I shall postulate, for the moment, the ad hoc constraint in (12), which later sections shall demonstrate to be in fact well grounded in the rightheadedness of Tianjin prosody as evidence by tonal stability (section 5 and section 6) and phonetically supported in experiments involving prominence perceptions of level and contour tones (section 7).

(12) *tt.t
Do not have ditonal sequences with the tone feature configuration [xy.z]

The constraint in (12) would militate against tonal sequences such as RL, RH, FH, FL, of which only RH and FL actually trigger tone sandhi. Although this is not a very promising start, it is not hopeless since within OT, the non-sandhi of RL and FH may be actually captured when *tt.t interacts with other constraints in the ranking hierarchy. This is illustrated in (13) where RL and FH are tolerated precisely because *tt.t is outranked by MAX[t]

(13) Tolerance of *tt.t violation

a. /RL/ (=/lh.l/)	MAX[t]	*tt.t
i. ☞ RL		*
ii. HL (=h.l)	*!	

b. /FH/ (=/hl.h/)		
i. ☞ FH		*
ii. LH (=l.h)	*!	

Now that there is a constraint ranking to prevent /RL/ and /FH/ from undergoing sandhi, one is ready to consider cases where *tt.t interacts with OCP[t] to trigger tone sandhi, which are: (1d) /FL/ → HL, (1e) /RF/ → LF and (1f) /RH/ → LH.

The cases (1e) /RF/→ LF and (1f) /RH/ → LH are more straightforward, involving primarily the strength of OCP[h].

(14) Strength of OCP[h]

a. /RF/ (=/lh.hl/)	OCP[h]	MAX[t]	*tt.t
i. RF	*!		
ii. ☞LF (=l.hl)		*	*

b. /RH/ (=/lh.h/)			
i. RH	*!		
ii. ☞LH (=l.h)		*	

Keeping the ranking MAX[t] »*tt.t established in (13) intact, (14) demonstrates that OCP[h] must rank higher than MAX[t] to trigger the tone sandhi in the case of RF→LF. In the case of RH→LH, *tt.t does not come into play.

The cases involving OCP[l] are more subtle. On the one hand, there is FR which does not undergo sandhi, while on the other there is /FL/→HL which does. To ensure, that FR stays unaltered, Max[t] must outrank OCP[l], as shown in (15).

(15) Tolerance of OCP[l] violation

Input: FR	MAX[t]	OCP[l]
i. ☞ FR		*
ii. HR	*!	

With (15), one now has a solution to one of the two mysterious graps, namely the non-sandhi of FR.

The constraint ranking in (15) makes it impossible to propose OCP[l]»MAX[t] as the reason for FL→HL. This is where *tt.t comes into play. With the help of *tt.t, local constraint conjunction (Smolensky 1993, 1995, 1997; Itô and Mester 1996, 1998; Krämer 2002; Padgett 2002; among others) with OCP[l] offers an explanation to why (1d) /FL → HL when FR does not undergo sandhi.

(16) Local Conjunction of Constraints (from Itô and Mester 1998:10))

a. Definition
Local conjunction is an operation on the constraint set forming composite constraints:
Let C_1 and C_2 be members of the constraint set *Con*. Then their local conjunction C_1 & C_2 is also a member of *Con*.

b. Interpretation
The local conjunction C_1 & C_2 is violated if and only if both C_1 and C_2 are violated in some domain .

c. Ranking (universal)
C_1 & C_2 » C_1
C_1 & C_2 » C_2

As mentioned before, the constraints that are to be conjoined would be *tt.t and OCP[l], with effects as shown in (17).

(17) Ganging-up effect of *tt.t & OCP[l]

Input: FL	*tt.t & OCP[l]	MAX[t]	*tt.t	OCP[l]
i. FL	*!		*	*
ii. ☞ HL		*		

In (17), one can see that an output FL would simultaneously violate both *tt.t and OCP[l], thus incurring also a violation of the conjoined *tt.t & OCP[l]. This is why it would be less parsimonious than HL.

The solution is nearly complete except for the issue of why HH does not trigger tone sandhi when RF and RH must alternate to become LF and LH respectively. The missing piece is the role of DEP[t], which will shield H from becoming F even at the face of OCP[h].

(18) Effects of DEP[t]

Input: HH	DEP[t]	OCP[h]	MAX[t]	*tt.t
i. ☞HH		*		
ii. LH	*!		*	
iii. FH	*!			*

In (18), the conjunction *tt.t &OCP[l] is irrelevant since HH does not involve any [l] adjacency. Hence when DEP[t] is ranked above OCP[h], OCP[h] cannot trigger alternation. Further, notice that HH does not incur violations of MAX[t], and is hence unlike RF and RH. In RF→LF and RH→LH, the alternations violate MAX[t] in favor of OCP[h], but in HH, the non-sandhi violates OCP[h] in favor of DEP[t].

The central role of *tt.t in the solution outlined thus far puts the spotlight on why LL→RL. This brings the discussion to the full circle when OCP[T] returns to the picture. For the present account involving *tt.t to work, OCP[L] must be undominated, as in (19), though one would at the moment not have a ranking argument for the order of OCP[l] and *tt.t.

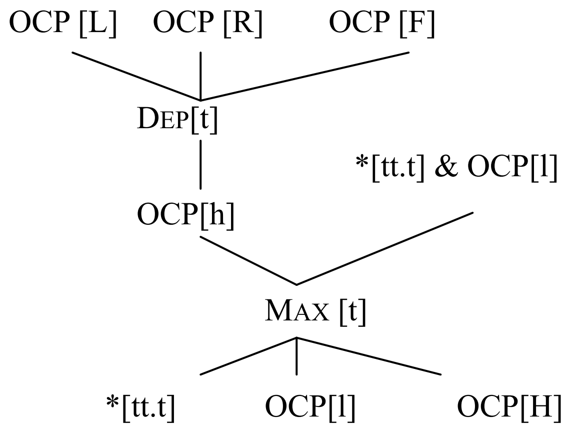
(19) Strength of OCP[L]

Input: LL	OCP[L]	DEP[t]	OCP[l]	*tt.t
i. ☞LL	*!		*	
ii. RL		*		*

In (19), one sees that LL→RL in order to satisfy the highest-ranked OCP[L], regardless of the violations of the other constraints.

When all the constraints discussed above are put together, a coherent ranking hierarchy would be as given in (20).

(20) Ranking Hierarchy for Tianjin Ditonal Sandhi



Evidently, OCP[L, R, F] must be ranked highest since they always trigger tone sandhi. The reason why HH doesn't undergo sandhi is due to low ranking OCP[H] and also the domination of DEP[t] over OCP[h], taking care of one of the two mysterious sandhi gaps. As for the other mysterious sandhi gap FR, this is accounted for with low ranking OCP[l], though the reason why FL→HL would be attributed to the ganging-up effect of OCP[l] and *tt.t.

All this looks like a very complex theory based on so few data points, but it must be noted that firstly, all the other constraints are independently motivated and can be shown to be universal; and secondly constraint conjunction has been independently shown to be a necessary tool in OT (as early as Mohanan 1993 in fact). The only novel item in the solution is *tt.t.

4. OCP, Tone Structure and Prosodic Headedness

The preceding section has shown that an account for the mysterious tone sandhi gaps is possible. Three things are crucial in the solution. Firstly the account requires OCP to apply at two levels: the tone contour and the tone features, which will be taken up further in section 4.1. Secondly, one would need some explanation as to why it is always the left tonal element that undergoes sandhi in a disyllabic sandhi sequence. Section 4.2 explains that this is due to the rightheadedness of Tianjin prosody, which will in turn reveal that the constraint *tt.t is in fact motivated by Tianjin prosody (section 4.3).

4.1 OCP and Tone Structure

In the account presented, OCP must apply at two levels, as shown in (21).

(21) tone contour ← OCP[Contour] applies at this level

tone feature   tone feature ← OCP[t] applies at this level

As long as one accepts a structural representation of tone which recognizes the contour as a unit composed of a sequence of level tones, the application of OCP at both levels in (22) is relatively uncontroversial. Since Tianjin tonal patterns do not appear to relate in any way to register (i.e. it does not require separation of the pitch range into two sections), the analysis given here is compatible with most models of tone structures (e.g. Yip 1980, 1989; Bao 1990, 1999; Duanmu 1990) proposed by phonologists studying Chinese tonal systems would all be compatible.[5]

However, the present account would not be compatible with any model that either construe of contours as a non-compositional unit only (such as Barrie 2007 or Hsieh 2008) or does away with contours as a unit recognizing only the constituent tone features. If contours are non-compositional, no form of OCP could apply so that RF→LF or RH→LH. Tianjin tone sandhi thus argues for the acceptance of contour tones as being made up of a sequence of level tone. Conversely, if one does not recognize the contour as a unit, then it would be impossible for OCP to trigger RR→HR and FF→LF. The only viable model for understanding contour tones would be (21).

A related difficulty is when the contour tone is simplex, such as H or L, both comprising of only [h] and [l] respectively. The question is if OCP[T] and OCP[t] are really one and the same in cases like H and L. The answer must be in the negative. Conceptually, the OCP that applies at the [T] level is blind to the OCP that applies at the [t] level. Confusing [h] with [H] or [l] with [L] would be fallacious: [H] is made of [h], but [h] can make [R] and [F] as well. Confusing [h] with [H] would result in claiming that R is made of [l] and H] rather than [l] and [h], which is logically incoherent.

4.2 Headedness from as seen from OCP[T]

The analysis presented thus far has ignored, out of convenience, the fact that ditonal sandhi applies to the first of the two tones, i.e. given a sandhi-triggering T_1T_2 sequence, it is T_1 that undergoes alternation. One straightforward explanation to this is that Tianjin prosody is right-headed, so that by positional faithfulness (Beckman 1998), the rightmost tone remains unchanged, illustrated in (22).

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5 For an excellent summary, see Yip (1995).

(22) IDENT-HD [T] (=MAX-HD-T in Yip 2002:89)

Tones corresponding to the prosodic head[6] may not undergo alternation.

/T_1T_2/	OCP[T]	IDENT-HD [T]	MAX[T]/DEP[t]
i. T_1T_2	*!		
☞ii. T'T_2			*
iii. T_1T'		*!	*

From the perspective of tonal stability, Tianjin is clearly right-headed. Given any length of a sandhi-triggering sequence, the rightmost tone would always be stable (see full data set for up to five syllables in Wee, Yan and Chen 2005).

However, Tianjin, like its sister Mandarin languages, has neutral-toned syllables (i.e. syllables which tone value are determined by the tone of the preceding syllable or by some kind of default pitch depending on the phonetic environment). The neutral tone creates complications when trying to determine if Tianjin prosody is indeed right-headed. This is because only non-initial syllables may carry the neutral tone. Neutral-toned syllables can occur in succession, a Tianjin example is given below (see Wang 2002a, b for a survey of neutral tones in Tianjin, Beijing, Shanghai and Urumqi; see also Li 2004:appendix II for a more comprehensive survey of eight Chinese dialects).

(23) Neutral tone in succession

xiaoR zi0 men0 de0

small diminutive plural possessive

'that belonging to the boys'

Neutral-toned syllables are indicated with "0". The neutral tone *zi* in (23) would surface with a high pitch from the [h] tonal element of the preceding syllable. The remaining neutral tone syllables surfaces with a gradual fall in pitch as they transit towards a low boundary tone on the rightmost edge. This illustrates that the neutral tone is indeed neutral since its pitch value is not part of the integrity of the syllable. The pitch value is entirely dependent on its environment.

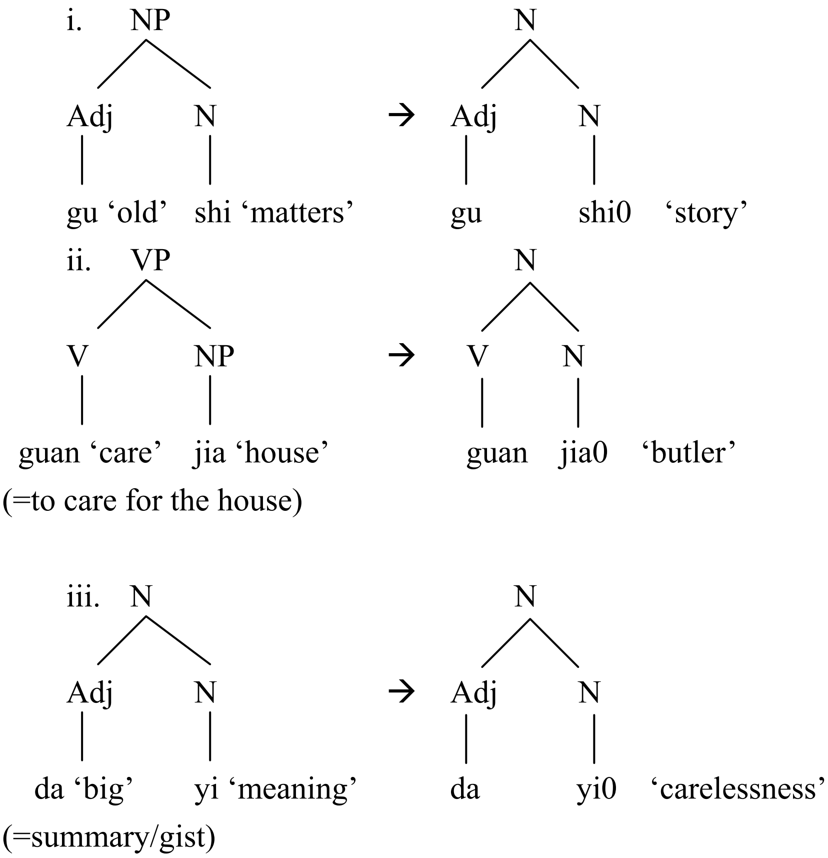
The existence of neutral tones has been used to argue for a left-headed prosody (notably Duanmu 2000). Since neutral-toned syllables are phonetically shorter than fully-toned ones, one could argue that disyllabic sequences where the second syllable is neutral-toned are trochaic. Though convincing, it does not follow that all disyllabic sequences are trochaic. Neutral-toned syllables typically, if not always, involve some amount of morphology: either

[6] Assumed here to be the rightmost element for Tianjin. One does not appeal to IDENT-RT[T], since as demonstrated in Nelson (1998, 2003), positional faithfulness may apply to elements on the left-edges, both edges, but never to the right edges alone.

the neutral-toned syllable is itself a suffix or it is the result of tonal reduction applying to an otherwise fully-toned syllable creating syntactic or semantic change. Some examples are given below in (24).[7]

(24) a. Suffix containing neutral-tone
   i. de0 ‘possessive marker’
   ii. men0 ‘plural marker’
   iii. zi0 ‘diminutive marker’

b. Syntactic/Semantic change



Thus, while Duanmu (2000) may be right that some Mandarin (including Tianjin) disyllabic sequences are possibly left-headed, it does not follow that Mandarin languages would have a default trochaic prosody. Interesting, the fact that neutral-tones always involve some degree of morphology argues for the position that Tianjin is by default prosodically right-headed.

[7] Examples apply both to Beijing and Tianjin Mandarin. I have not indicated the tones of non-neutral toned syllables since Beijing and Tianjin have different tone values for these syllables.

4.3 *tt.t as Ban on Tone Trochees

As can be seen from the considerations above, the issue of headedness in Tianjin is closely tied to tonal properties. The issue of right-headedness is reminiscent of *tt.t which forbids a disyllabic sequences where the first syllable bears a contour tone and the second a simplex tone. This section shall explain that *tt.t is in fact a ban against disyllabic forms that do not accord with the iambic default of Tianjin prosody.

Notice that all Tianjin toned monosyllables are prosodic words, neutral toned monosyllables are not prosodic words. Neutral tone syllables are perceived as short, even though there are examples like [mən] or [tien] which would not be short in terms of rime segments. Generally, syllables are not distinct in terms of rime weight/length. It follows that tones are really what contribute to weight units in Tianjin, not rime segments. Since a minimal prosodic word must be a foot, the status of prosodic word in Tianjin is dependent on tone presence, not segment count. Consequently, the presence of a tone feature is likely to contribute to prosodic weight. If so, then a syllable that has a contour tone is potentially construed as heavier than a syllable with a simple tone, i.e. [tt] is heavy but [t] is light. Having explained that Tianjin is iambic in section 5.1, disyllabic sequences with tone configuration [tt.t] would not be as parsimonious as disyllabic sequences with tone configurations [t.tt] or [t.t]. This leads to the understanding that a constraint *tt.t is really a ban on trochees for a prosodically right-headed language like Tianjin, so the constraint is not ad hoc after all.

5. Phonological Evidence for Tonic Weight

Interpreting *tt.t as a ban against trochees in a prosodically rightheaded language such as Tianjin implies that tone features serve as weight units. This section presents some evidence for such a view.

In Tianjin, deliberate stress blocks sandhi (Wee, Chen and Yan 2005).[8] Given a sandhi pattern XY → X'Y, sandhi can be blocked if the X receives deliberate stress. Deliberately stressing a syllable, say for emphatic or contrastive purposes, puts prosodic headship on that syllable by virtue of its prominence. This would impact on the iambic or trochaic status of the XY sequence, making the target of sandhi immune to alternation. This harks back to the earlier discussion in section 4.2 that the stable tone is the prosodic head.

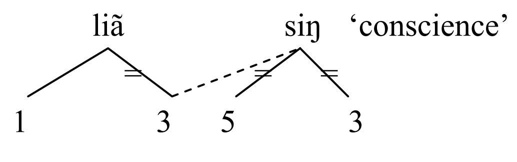
[8] Thanks also to Jenny Zhijie Wang who is a native speaker of Tianjin for confirming these observations.

(25) Sandhi-blocking by Stress (cf. (1))

a. where LL → RL is blocked
  i. ***feiL*** *jiL* not ***feiR*** *jiL* ‘fly machine (=airplane)’
  ii. ***kaiL*** *cheL* not ***kaiR*** *cheL* ‘drive car’
b. where RR → HR is blocked
  i. ***zongR*** *liR* not ***zongH*** *liR* ‘overall manage (=prime minister)’
  ii. ***xuanR*** *juR* not ***xuanH*** *juR* ‘select support (=election)’
c. where FF → LF is blocked
  i. ***fuF*** *guiF* not ***fuL*** *guiF* ‘prosperity expensive (=prosperous)’
  ii. ***shiF*** *jieF* not ***shiL*** *jieF* ‘world domain (=world)’
d. where FL →HL is blocked
  i. ***siF*** *fangL* not ***siH*** *fangL* ‘four square (=square)’
  ii. ***qiF*** *cheL* not ***qiH*** *cheL* ‘gas vehicle (=car)’
e. where RF → LF is blocked
  i. ***banR*** *dengF* not ***banL*** *dengF* ‘board chair (=bench)’
  ii. ***shouR*** *duanF* not ***shouL*** *duanF* ‘hand segment (=methods, means)’
f. RH → LH
  i. ***zhaoR*** *qianH* not ***zhaoL*** *qianH* ‘find money (=give change)’
  ii. ***zhuR*** *renH* not ***zhuL*** *renH* ‘master person (=master/mistress)’

That prosodic heads are tonally-manifest is not unique to Tianjin. Word-level tone in other Chinese languages is best understood if we assume that the tone source is the metrical head. In Shanghai for example, the tonal features of the first syllable spreads to the right-adjacent one which dissociates its original tone, illustrated below in (26).

(26) Shanghai Tone Sandhi
liã13 ‘good’ + siŋ35 ‘heart’ → liã1 siŋ3 ‘conscience (=good heart)’



Patterns like Shanghai is best understood along lines of headedness. In this case, the leftmost syllable is the head, which is why the tones are preserved. The non-head syllable loses its tone features precisely because of its non-head status and then inherits a tonal feature supplied by the head syllable. Again, one sees the close correlation between headship and tones: that which is head has tones, and that which is not has not; or that which has tones is head, and that which has not is not.

Evidence from sandhi-blocking due to stress or from dissociation allows us to infer that tone feature [t] contributes directly to weight. A more direct way of testing this is to run a perception experiment on Chinese speakers.

6. Perception Experiment

If the implications of *tt.t are right, then contour tones must be perceptually more prominent than simplex tones. To test this, I constructed a set of stimuli as follows.

(27) Stimuli

Digitally constructed tone sequences using Praat.
12 sequences, each 6 alternating tones
1 control sequence of 6 random noise bursts
Each tone/noise burst is 0.2s, separated by 0.1s of silence.
Pitch interval of 450Hz – 300Hz
Tone = H, L, R, F

The experiment is run on 30 subjects who speak a Chinese language as a native language. There is a mixture of men and women from various linguistic backgrounds ranging from speakers of Chinese dialects from Hong Kong, Shanghai, Anhui, Tianjin, Beijing, Yunan, Guangxi, Sichuan, Hunan, Zhejiang, and Shaanxi.

Subjects are given a blank form as shown in (28).

(28) Form for Perceptual Experiment

PERCEPTION EXPERIMENT

Preamble: You will hear 12 strings of tones. For each string, please circle any item you think sounds more prominent to you.

Sound sequence base
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 1
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 2
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 3
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 4
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 5
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 6
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 7
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 8
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 9
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 10
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 11
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

Sound sequence 12
σ_1 σ_2 σ_3 σ_4 σ_5 σ_6

I am MALE / FEMALE, and I am ____ years old. My native language is/are ____. I am from ______________________________.

The subjects are played each sound sequence and asked to circle any σ in each string that they feel are more prominent in any way. They can circle more than one or none at all. Subjects are also told that there are no right or wrong answers. The fact that each sound is in fact equal in length and amplitude is deliberately hidden from the subjects. Subjects are allowed to hear any sequence as many times as they wish and are told that they can take as much time as they want. However, it turned out that repetitions were barely requested, and requests for more time were also virtually absent. The ease with which subjects did the experiment suggests that they are relatively sure-footed in terms of what they perceive to be prominent.

The table below presents the results.

(29) Results of the perceptual experiment

Sequence Base																	
X	X	X	X	X	X												
14	6	**8**	7	6	**8**												
Sequence 3						Sequence 9						Sequence 11					
L	H	L	H	L	H	L	F	L	F	L	F	L	R	L	R	L	R
10	**13**	9	**12**	7	**9**	12	**13**	10	10	12	**12**	11	**15**	7	**14**	9	**12**
Sequence 1						Sequence 7						Sequence 5					
H	L	H	L	H	L	F	L	F	L	F	L	R	L	R	L	R	L
12	9	**10**	9	**13**	11	**15**	7	**18**	5	**13**	7	**16**	8	**14**	7	**15**	6
Sequence 2						Sequence 8											
H	F	H	F	H	F	H	R	H	R	H	R						
5	**16**	4	**14**	7	**14**	8	**17**	7	**15**	6	**15**						
Sequence 4						Sequence 10											
F	H	F	H	F	H	R	H	R	H	R	H						
17	5	**13**	4	**13**	7	**12**	7	**12**	9	**15**	9						
Sequence 12						Sequence 6											
F	R	F	R	F	R	R	F	R	F	R	F						
14	7	**14**	6	**14**	6	10	**11**	10	**12**	9	**10**						

In the table above, the numbers indicate the number of respondents who found the corresponding item prominent in the sequence. The base sequence contains no tonal element, just burst of random noise, and it shows that most respondents feel that the initial, third and final bursts to be more prominent than the others. These are indicated with boldface. There is a left-edge prominence bias.

Despite the left-edge prominence, ultimately it is the contour tone that prevailed as more prominent as can be seen in the other sequences. Comparing sequence 9 and sequence 7 for example, most respondents perceive F to be more prominent than L, regardless of whether F or L initiates the sequence. The same can be seen in a comparison between sequence 8 and sequence 10 where R and H are compared. In general, the perception experiment suggests that generally, F is most prominent followed by R, which is more prominent than H which in turn is more prominent than L. That F is perceived as more prominent than R may strike some as peculiar since the typical markedness hierarchy is that a rising tone is more marked than a falling tone. The markedness hierarchy is motivated by the observation that rising tones are phonetically harder to produce than a falling one, which is essentially an argument based on articulatory effort. That the perception hierarch is different should not come as a surprise.

The results of this very simple perceptual experiment support that idea that tone features contribute to prosodic prominence, which translates into prosodic weight.

7. Conclusion

Tianjin ditonal sandhi is a clear case of OCP-triggered alternation. However, two mysterious gaps have hitherto not been adequately addressed. By assuming that Tianjin is prosodically right-headed, the kinds of absorption tone sandhi in Tianjin can be attributed to a combination of OCP at the level of tonal features and the need to reflect the iambicity of a disyllabic string through a tone sequence that is not trochaic (i.e. *tt.t).

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